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Checklist of millipedes (Diplopoda), centipedes (Chilopoda) and scorpions (Arachnida: Scorpionida) from a savanna ecosystem, Limpopo Province, South Africa

by

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ABSTRACT

The savanna biome covers one third of South Africa and is important in the livestock, game and ecotourism industries in the country. Although the mammalian and floral components of this biome have been extensively studied, the invertebrate components have not. Conservation agencies have recognized the importance of biodiversity and many have shifted the management focus away from large mammals to biodiversity in general. This has led to the need for information on the invertebrate fauna of protected areas. This study formed part of a broader investigation of the factors affecting millipede, centipede and scorpion diversity in a savanna environment. Millipedes, centipedes and scorpions were sampled in the Greater Makalali Conservancy, Limpopo province, at 45 sites during two seasons, late summer (February/March 1999 and February/March 2000) and early summer (October/November 1999). Pitfall traps, active searching of random and nested quadrats, cryptozoan traps and wet cloths were used in sampling five different habitat types. In addition, some material was collected outside of the 45 sites in 1998 or during the sampling period, and records from another study in the Conservancy in 2000 and 2001 have also been included. Fourteen millipede species representing nine genera, within six families and three orders were sampled; 88 centipede specimens were sampled, representing six species (one undescribed), five genera and two orders; 76 scorpion specimens were collected, which included nine species belonging to six genera and three families. The high number of specimens, local specialists and restricted distribution species, indicate the importance of the savanna biome for the conservation of these three invertebrate groups.

INTRODUCTION

The savanna biome covers over half the land surface in Africa and one fifth of the land surface in the world (Scholes & Walker 1993). In southern Africa, the savanna biome occupies 46% of the area, whereas in South Africa it covers over one third of the country (Low & Rebelo 1996; Stuart-Hill & Tainton 1999). In addition to covering a large proportion of the land surface, the savanna biome is important for the contribution that it makes to the livestock and ecotourism industries in South Africa, and for its high plant diversity (Scholes & Walker 1993). This biome has been relatively well studied in terms of large mammals and plant species. However, the importance of conserving all components of biodiversity is increasingly recognized among conservationists. In order to conserve biological diversity within a particular area however, one needs to know what species are present, as well as to have information on species' distributions. Regional or local checklists are also important because they provide baseline data for use in assessing the conservation value of an area, and for monitoring impacts of management practices or environmental changes. Simple checklists are generally lacking for invertebrates across most of South Africa.

The checklist presented here is part of a larger investigation, which will be published elsewhere, into the factors affecting millipede, centipede and scorpion diversity in savanna ecosystems. These taxa are all large-bodied, conspicuous, with limited vagility, and they represent detritivores (millipedes) and predators (scorpions and centipedes). Few quantified regional or local surveys and checklists have been published for millipedes, centipedes and scorpions.

Although South Africa contains a high number of millipede species (currently 451 described species) (Hamer 1998) and millipede diversity has been relatively well documented, there has been collecting bias within the region and many areas have not been sampled (Hamer 1997; Hamer & Slotow 2002). Much of the millipede sampling in the past has focused on sampling in forest or closed canopy environments as opposed to the more open savanna environment. Lawrence (1967) did report on and describe several new millipede species from the Kruger National Park, which is adjacent to the study area. Millipedes have limited powers of dispersal and a high degree of speciation, which has resulted in the evolution of a large number of range-restricted endemics (Hopkin & Read 1992).

Within South Africa there are approximately 130 known centipede species in four orders (Lawrence 1955). They are a potentially important group of organisms for ecological studies because their diversity appears to correlate with habitat characteristics of certain vegetation types (Zapparoli 1992) and they are sensitive to environmental changes (Kos 1992). There is a dearth of knowledge about centipedes within the savanna biome of South Africa, with the only comprehensive coverage of South African centipedes dating back to that by Lawrence (1955).

Although detailed studies on scorpions have been conducted within the savanna biome in the Kruger National Park in South Africa (Lawrence 1964, 1967; Newlands 1972), other areas within this biome have not been nearly as extensively studied. Few of the species sampled within the Kruger National Park were found to be widespread in their distribution (Lawrence 1964, 1967), suggesting that further diversity studies, even within the savanna biome, may produce new distribution records and possibly even new species. Approximately 100 described scorpion species have been recorded from South Africa (Prendini 1995, 2001*a*, *b*, *c*, 2004, in press; Fet *et al.* 2000), but at least 25 additional species remain to be described from the country (Prendini in prep.).

STUDY AREA

The study was carried out in the Greater Makalali Conservancy, which is situated in the foothills of the Drakensberg Mountains in Limpopo Province, South Africa (24°09'15"S: 30°41'57"E). The Conservancy covers 14 500 ha, is situated on the Lowveld plain at an altitude of between 300 and 500 m above sea level and is found within the savanna biome of southern Africa with Mixed Lowveld Bushveld (Low & Rebelo 1996, Type 19) and Mopane Bushveld (Low & Rebelo 1996, Type 10) as the main vegetation types. Makalali has an average annual rainfall of 450 mm. Most of the rain falls in the summer months between October and March. Temperatures in the reserve vary between 3°C in winter to above 36°C in summer.

For this study, five different habitat types were determined visually, using differences in vegetation type and soil characteristics (Table 1). Three sites in each habitat type

TABLE 1

Characteristics of the five habitats sampled in the Greater Makalali Conservancy.

Habitat type	Vegetation type	Sand type	Soil colour	Rocks present
1. white sandy bushveld	mixed bushveld	coarse	white	no
2. brown sandy bushveld	mixed bushveld	medium	brown	no
3. general mixed bushveld	mixed bushveld	coarse	brown	yes
4. rocky outcrop	mixed bushveld	coarse	brown	yes
5. mopane woodland	mopane	loamy	brown	no

were sampled in three sampling periods: twice in late summer (February–March 1999 and February–March 2000) and once in early summer (October–November 1999), resulting in 45 sites being sampled throughout the study.

MATERIALS AND METHODS

The focal taxa were sampled using six different methods. During all three sampling periods pitfall traps and active searching of both nested and random quadrats were used. At each site one 25 m^2 nested quadrat, consisting of five nested blocks measuring 1x1 m, 2x2 m, 3x3 m, 4x4 m and 5x5 m, and randomly placed at the site, was searched. Searching involved actively sifting through leaf litter, removing the top layer of soil with a trowel, and by turning over rocks and branches. All trees and shrubs that fell in the quadrat were also searched up to a height of 2 m. There was no time limit set for searching because the amount of time required to sample the quadrat completely, varied according to the structural complexity of the habitat. Ten 2.25 m^2 random quadrats were set up at each site, along lines radiating from the four corners of the nested quadrat (see Druce *et al.* 2004, Fig. 1). Random numbers were used to determine the distance from the corner for each quadrat. The random quadrats were searched in the same way as the nested quadrat. Ten pitfall traps were set at each site, in two rows of five, with each trap 10 m away from neighbouring traps. The traps used were glass test tubes with a diameter of 18 mm and a height of 150 mm. These relatively small traps were selected to reduce the time required for processing samples, and also for preventing larger predators from getting into traps. Pitfall traps were left in place for two weeks. In February to March 1999 cryptozoan traps (flat boards placed under leaf litter, baited with carrot and butternut, and left for two weeks) were used. During this sampling period wet cloths tied in trees and left for two weeks were also used in an attempt to sample tree dwelling species which live under bark. These and the cryptozoan traps had limited success in sampling any of the focal taxa (Druce *et al.* 2004). Drive transects were used in February to March 2000. This sampling was conducted in the early morning (between 07:00 and 09:00) and late afternoon (between 16:30 and 18:30). Two routes through the reserve were selected that traversed the five habitat types. Each transect was driven in both directions four times, twice in the morning and twice in the afternoon. Any specimens in the road were recorded after examining and identifying or collecting the specimen. Details of the effectiveness and efficiency of these methods for millipedes, centipedes and scorpions are presented in Druce *et al.* (2004). Berlese sampling was considered, but not used because leaf litter was seldom present in sufficient quantities at the study sites, and the hardness of the soil limited the use of this technique in the savanna habitat. Some species were collected outside the study sites during a preliminary

TABLE 2
Checklist of species collected within the Greater Makalali Conservancy.

Their local status (Lo Status), whether generalist (G) or specialist (S) is given for within the Greater Makalali Conservancy, together with the total number of specimens recorded during the study (No. Ind.). Distribution data are provided by country, with more specific detail provided for South Africa. Localities are abbreviated as follows: KNP = Kruger National Park; KZN = KwaZulu-Natal; Mpu = Mpumalanga; LP = Limpopo Province; NWP = North West Province; WC = Western Cape; SA = South Africa. Species not found at actual study sites but found elsewhere in the Conservancy are indicated by *. Potentially new species indicated by **sp. n.** (for Habitat types 1–5, see Table 1.)

	Habitat					**Lo Status (No. Ind.)**	**Known Distribution**
	1	**2**	**3**	**4**	**5**		
DIPLOPODA							
1. Order Spirostreptida, Family Spirostreptida							
Synophryostreptus rugosostriatus (Schubart, 1966)				x	x	S (11)	SA (KNP; LP; Mpu)
Doratogonus rugifrons (Attems, 1922)	x	x	x		x	G (32)	Botswana; Namibia; SA (Gauteng; LP; NWP)
Doratogonus flavifilis (Peters, 1855)	x	x		x	x	G (9)	Mozambique; SA (KNP; north east KZN; LP; Mpu) Zimbabwe; Zambia
Spirostreptus kruegeri (Attems, 1928)	x	x			x	G (34)	Botswana; SA (Gauteng; LP)
2. Order Spirostreptida, Family Harpagophoridae							
Zinophora similis (Carl, 1917)	x	x	x	x	x	G (75)	Mozambique; SA (Gauteng; KNP; Mpu; LP)
3. Order Spirostreptida, Family Odontopygidae							
Chaleponcus acanthophorus Attems, 1928				x		S (21)	SA (LP)
**Chaleponcus digitatus* Kraus, 1966					x	S (12)	SA (KNP; LP)
Spinotarsus colosseus (Attems, 1928)	x					S (1)	SA (KNP; KZN; LP)
Spinotarsus cf. *modestus* (Attems, 1928)	x	x	x	x	x	G (334)	Mozambique; SA (LP)
Spinotarsus skukuzicus Kraus, 1966	x	x	x	x	x	G (441)	SA (KNP; LP)
4. Order Polydesmida, Family Dalodesmidae							
Gnomeskelus cf. *skukuzae* Lawrence, 1967					x	S (3)	SA (KNP; LP)
5. Order Polydesmida, Family Gomphodesmidae							
**Ulodesmus macrodontus* Lawrence, 1967	x	x	x	x	x	G (75)	SA (KNP; LP)
6. Order Sphaerotheriida, Family Sphaerotheriidae							
Sphaerotherium modestum Attems, 1928		x	x	x	x	G (377)	SA (KNP; LP)
CHILOPODA							
1. Order Geophilomorpha							
Orphnaeus brevilabiatus Newport, 1845	x		x	x	x	G (10)	SA (KNP; LP); Zimbabwe

2. Order Scolopendromorpha							
Cormocephalus westwoodi dispar Porat, 1893						(1)	Lesotho; SA (KZN; LP; Mpu; WC)
**Ethmostigmus trigonopodus* (Leach, 1817)						S (1)	SA (KNP; Mpu; LP); Tanzania, Zimbabwe
Scolopendra morsitans Linne, 1758	x	x	x	x	x	G (53)	Angola; Lesotho; Mozambique; Namibia; SA (KNP; KZN; LP); Zambia; Zimbabwe
Scolopendra **sp. n.**	x	x	x	x	x	G (25)	SA (LP)
**Trachycormocephalus afer* (Meinert, 1886)						(1)	SA (LP); Zimbabwe
SCORPIONIDA							
1. Family: Liochelidae							
Cheloctonus jonesii Pocock, 1892			x			S (1)	Mozambique; SA (KNP; KZN; LP); Swaziland; Zimbabwe
Hadogenes troglodytes (Peters, 1861)					x	S (1)	Botswana; Mozambique; SA (KNP; LP); Zimbabwe
**Opisthacanthus asper* (Peters, 1861)						S (1)	Botswana; Kenya; Malawi; Mozambique; SA (KNP; LP); Tanzania; Zimbabwe
2. Family Scorpionidae							
Opistophthalmus boehmei (Kraepelin, 1860)	x					S	Botswana; Mozambique; SA (KNP; LP); Tanzania; Zimbabwe
Opistophthalmus glabrifrons Peters, 1861	x	x				S (2)	Botswana; Malawi; Mozambique; SA (KNP; LP); Swaziland; Tanzania; Zimbabwe
3. Family: Buthidae							
Parabuthus mossambicensis (Peters, 1861)		x	x	x	x	G	Botswana; Mozambique; SA (KNP; LP); Zambia; Zimbabwe
Parabuthus transvaalicus Purcell, 1899	x	x	x	x	x	G (22)	Botswana; Mozambique; SA (KNP; LP); Zimbabwe
Uroplectes carinatus (Pocock, 1890)			x	x		S (6)	Angola; Botswana; Namibia; SA (KNP; LP); Zimbabwe
Uroplectes olivaceus Pocock, 1896	x		x	x	x	G (15)	Mozambique; SA (KNP; LP); Swaziland; Zimbabwe

and during another study in the Conservancy, and these are included in the checklist but the abundance figures for these species are not comparable to those from the quantified sampling.

During the first sampling period in February to March 1999, most specimens were collected, and only those which were undoubtedly replicates were released. These were then all identified by expert taxonomists and descriptions based on external characteristics were drawn up to enable subsequent identification in the field. In all cases, species within the different orders of centipedes and millipedes could be differentiated by external characters such as colour, patterning and size. Most of the scorpions were collected in pitfall traps (Druce *et al.* 2004) and specimens were therefore kept for expert identification, but those sampled by the other methods could be distinguished by size and colour, and by size and shape of the pincers and tail. This meant that in the case of active searching, once recorded, specimens could be released, and only those specimens for which there was any uncertainty regarding identity were collected. All specimens collected have been accessioned into the collections of the Natal Museum, Pietermaritzburg, KwaZulu-Natal.

All species sampled were classified as either generalists or specialists at the local scale (within Greater Makalali Conservancy). Local scale specialists were species that were sampled in less than three habitat types during the study, whereas local generalists were sampled in three or more habitat types. Distribution data for millipedes were obtained from Hamer (1998), centipede data from Dobroruka (1968, 1969), Lawrence (1955), Lewis (1969, 2001) and Schileyko & Stagl (2004), and scorpion data were obtained from Prendini (1995, 2001*a*, *b*, *c*, 2004, in press, unpublished data).

RESULTS

A total of 1430 millipede specimens was sampled in the Greater Makalali Conservancy. These represented 14 species belonging to nine genera, within six families and three orders. Many additional juvenile millipede specimens were collected but could not be identified to species, or in some cases, even genus level. The 88 centipede specimens collected represented six species in five genera and two orders, whereas the 76 scorpion specimens collected represented nine species belonging to six genera and three families (Table 2). One new centipede species was discovered and the millipede species *Spinotarsus* cf. *modestus* may represent a new species, but further taxonomic work on this large genus (96 known species) is required to confirm the identity of the specimens. The situation is similar for *Sphaerotherium* sp., with taxonomic work being required before these specimens can be identified with any confidence.

DISCUSSION

The discovery of a new centipede species in the Greater Makalali Conservancy, as well as the high number of millipede and scorpion specialists at a local scale, indicates the importance of the savanna biome for the conservation of these groups. Eight of the millipede species could be considered local or regional endemics (see Hamer & Slotow 2002 for definitions) because they have only been recorded from the Kruger National Park and the area surrounding it. The Makalali record for the scorpion *O. boehemi* represents the southernmost locality for this species.

Although it was thought that moister environments support greater numbers of millipede and centipede species and individuals due to the higher quantities of moist decomposing material, the large number of millipede individuals sampled in the Conservancy (1430) indicates that the drier savanna environment is also an important habitat. This study has also highlighted the need for more extensive sampling within the savanna biome in order to develop a more complete understanding of the invertebrate diversity of this biome.

Although a wide variety of sampling methods was tested, sampling was only carried out for a limited period. Not all species present in the Conservancy were sampled during this period, as indicated by the discovery of several species outside of the sample sites. One problem with the study, at least in terms of scorpions, was the absence of night sampling using UV light detection methods. This method is recognized as being more effective than those methods used, but was not feasible because of the difficulties of night sampling in a reserve with large predators such as leopards and lions.

None of the focus taxa could be considered to be highly seasonal, and while most species are present year-round, some species were only sampled either early or late in the summer (Druce *et al*. 2004). Millipedes and possibly centipedes are more likely to be active and therefore more easily sampled in wet, rainy conditions, and more sampling under these conditions may provide additional species. Scorpions are best collected at night in warm dry periods, and this may have limited the number and diversity of scorpions sampled during the study.

Sampling a wider range of habitats will result in additional species being added to the checklist. Evidence for this is the large proportion of specialist species that are restricted to particular habitats, which suggests that millipedes, centipedes and scorpions species do not occur uniformly throughout all vegetation classified as savanna.

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